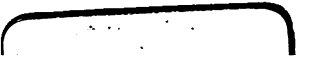

EVERY-DAY WONDERS;

OR,

FACTS IN PHYSIOLOGY

WHICH ALL SHOULD KNOW.

Illustrated with Woodcuts.

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CONTENTS.

PREFACE.

THE object of the writer of this book has been to present a few of the truths of that science, which treats of the structure of the human body, and of the adaptation of the external world to it, in such a form, as that they shall be readily apprehended by children and young people. The lively interest which intelligent children would take in the works of God, within and around them, is frequently checked by the manner in which they are introduced to the study of Science. Portions of elementary scientific books are required to be learnt as task-work, and the learner inwardly condemns the subject as "dry," and abandons all farther pursuit of it when at liberty to do so.

Where a teacher communicates orally such a thorough explanation of the terms employed, and such familiar illustrations as

may enable the child, not only to *remember words*, but to *apprehend truths*, the child's wonder and delight are excited, and such a beginning is likely to awaken sufficient energy, to lead to sound and valuable acquisitions.

The writer disclaims any wish to represent the attainment of Science as an easy work. But for the very reason that the path is toilsome, it is surely unwise to scare the learner from the entrance.

It is attempted in this little book to supply the explanations and illustrations by which a teacher would win the attention of a child.

For this purpose it has been thought better to *dwell* on a *few* facts than to crowd the book with many. Pains have been taken that all the information imparted should be accurate.

EVERY-DAY WONDERS;

OR,

FACTS IN PHYSIOLOGY.

CHAPTER I.

ON THE AIR.

Do you know what the air is? Can you see it? The room is full of air. We cannot see the air in the room. If you look out of the window when the air is moving, that is, when the wind is blowing, though you cannot see the air, you can see what it does. There is a lady walking across a field. She is strong, but the air (which we cannot see) pushes her so hard that she can scarcely stand. The air (which

we cannot see) has been known to push down houses, and to root up trees, and to tear the sails of ships into little strips.

Fig. 1.

We cannot say, then, that there is nothing in the room because there is only air in it. What is the air made of? You shall hear more of that presently. First think what is the use of it. If there were really nothing at all in this room you would die and I should die, we should all drop down

dead. The air is good to keep us alive. God made it for this purpose. Several light substances are mixed together to make the air, and if one of them were taken away from the rest, we should die.

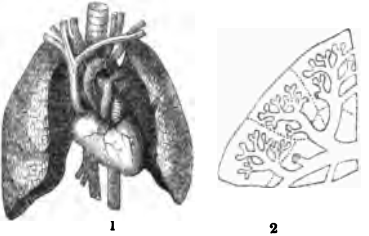
How does the air keep us alive? Do we eat it? No, we can see the things we eat. Do we drink it? No, we can see the things we drink.

We feed on air oftener than we eat or drink. We must eat and drink several times a day, but not every moment. But we must feed on air every moment, that is, we must breathe; breathing is feeding on air. Now when we eat we do not like to eat dirty and unwholesome food. We should not like to eat clay mixed with our bread. But many people who would not mix unwholesome things with what they eat and drink, feed on what is unwholesome by breathing, without knowing what they are about. I will tell you the use of good wholesome air. Inside the upper part of your body, you have two things called

lungs. They are something like sponges; they have so many little holes in them. When you dip a dry sponge in water, and then squeeze it you can see how much water the holes of it will contain.

The holes or cells in the lungs are intended to contain air. Here is a picture of the lungs. Each cell is made of a thin membrane

Fig. 2.*



1 2

or skin. One large pipe, called the windpipe, branches out into a great number of smaller pipes, and each of the little pipes ends in a cell, as may be seen in this drawing.

* 1, Lungs with windpipe. 2, Diagram of the termination of the bronchial tubes in air-cells.

Every time you breathe you fill your lungs with air. Take a deep breath. That breath will not last you long, for the air has to be taken in and again let out of our lungs every moment. If you were to leave off taking it in and letting it out you would soon die. All night as well as all day you must go on breathing. You have heard of the two little princes who were smothered in the Tower. A bad man stopped their mouths and noses, so that no air could get into their lungs, and they died. When the air gets into the lungs of what use is it then? I will tell you. There are many things inside your body beside your lungs: there is your blood. Now the blood requires air to make it red and healthy, pure and good. You know the difference between pure and impure water. When you are thirsty how refreshing to drink a glass of pure water, but you must be almost dying with thirst before you could drink muddy putrid water.

It is as necessary to health that you

should breathe good fresh air, as that you should drink pure water when you are thirsty. Part of the air which you take into your lungs passes through the thin skin of the cells of which the lungs are made. It goes into the blood and makes it red and healthy. When we see a healthy child who runs about in the fresh air, its cheeks are rosy and its lips are red, because the good air has passed from the lungs into the blood and coloured it so brightly.

CHAPTER II.

ON THE GASES WHICH FORM THE AIR.

I SAID that there were several light substances mixed together to make the air. These light substances are called gases. Did you ever observe a lamp-lighter lighting the gas-lamps in the street? He turns a cock, and a light substance called gas comes out. This gas can be got out of coals by burning them. The coals are burnt in a place called a gasometer. The gas which comes out of them, and which burns so brightly in the gas-lamp, runs into pipes which are placed under ground (to be out of the way), and the pipes are continued up the lamp-

Fig. 3.*

* Gaslight and cock.

posts. When the lamp-lighter turns the cock, some of this gas comes out; though it is so thin it cannot be seen (any more than the air we breathe), yet the moment a light is put to it, it becomes a flame, and the flame burns on until the cock is again turned, and the gas can no more come out. There are many different gases. The air we breathe is made of two gases, and there is in it a very small mixture of a third gas. One of these gases is necessary to our life, the other (though it would kill us if we breathed it alone) is necessary to mix with the other gas which is good for life. The gas which keeps us alive is too strong alone; just as some medicines which are very useful when taken mixed with water would kill us if taken unmixed with water. The gas necessary for life is called oxygen gas. The gas put with it, which makes it weaker, is called nitrogen gas. There is only a very small quantity of the third gas, called carbonic acid gas, and this third gas would kill us if we breathed it alone.

Now I will show you by a picture how much of the three gases are put together to make the air. Here is the picture of a bottle. It is divided into five parts, by little ridges on the outside.

Fig. 4.*

If wine were poured in to fill the lowest division, and the rest of the bottle were filled up with water, the wine would represent the quantity of oxygen gas, and the water the quantity of nitrogen gas. If one drop of milk were now dropped into the bottle, that drop would represent the quantity of carbonic acid gas.

Carbonic acid gas is a deadly poison. If all the air were made of it we should die.

There is a grotto in Italy called the Grotto of the Dogs. The gas called carbonic acid gas comes out of the ground in that grotto.

* Drawing of a bottle with five equal divisions.

To show how poisonous that gas is, the people who live near it sometimes put a dog into it for a few minutes. When they take the poor animal out he looks as if he were dead; if they left him there long he would die. But they do not wish to kill him, they dash water over him, and let him again breathe the fresh air, and he recovers. This shows how very poisonous the carbonic acid gas is.

CHAPTER III.

ON BREATHING.—STORY OF THE "LONDONDERRY."

You have now learnt the names of those light substances, called gases, which make the air we breathe, and I dare say you can easily remember their names, and what quantity of each there is in the air. Repeat the names and the quantities. You shall now hear how these gases are used when we breathe them. At every breath we take in the three gases, but only one of them is used to support our life. This is the oxygen gas; it passes into the blood. The blood does not remain still in our body; it runs through it. When it comes to the lungs it is of a dark colour, and this dark colour is occasioned by the same kind of gas which comes out of the earth

in the grotto of which you have read. The oxygen gas which we breathe with the air, goes through the thin skin of the cells of the lungs into the blood, and changes the colour of it to a bright red.

The carbonic acid gas, which had made the blood so dark, now gets into the cells of the lungs, and we breathe it out again into the air of the room. So you see we take in to our lungs oxygen gas, nitrogen gas, and the very least portion of carbonic acid gas, and we pass out of our lungs every time we breathe the same quantity of nitrogen gas, a less quantity of oxygen gas, and much more carbonic acid gas than before.

Now it is very useful and necessary to know this, because a great many people may be sitting together in a room, and while they are thinking nothing about it, they may be injuring themselves and one another, and that without knowing that they are doing any harm at all. Every person in the room is using up some of the oxygen gas, (and remember only one fifth part is

oxygen gas,) and every person is also breathing out the carbonic acid gas which destroys life. It is a very happy thing for us all that air can get through little crevices, for if we shut our doors and windows, and put a board before our fire-place, we still cannot exclude all the fresh air from our rooms. If we could quite shut out the fresh air, and if many were in one room together they would die. The weakest would die first, but whether weak or strong all would die in no long time.

Not very long ago a ship with a great number of passengers on board, set sail from the western coast of Ireland towards Waterford.

The passengers were poor emigrants who could not make a living at home, and were going to America by way of Liverpool, to see if they could find work there.

As they sailed along, the wind rose higher and higher, and at last blew tempestuously. The captain had taken more passengers than his vessel could comfortably accommodate.

The sea beat over the deck of the vessel. The crew of sailors who understood how to obey the captain's orders in managing the sails and rigging, could not do their duty while frightened men and women and children crowded the deck.

The captain ordered all the passengers to go below. They went into their cabin, and were very much crowded together in it. There was, however, a hole in the deck, through which air came to them, but with the air the sea water dashed down it in large quantities. The captain ordered that a tarpaulin (a cloth through which neither water nor air can pass), should be nailed over this opening. The sea and winds roared so loudly, that the voices of the people below could not be heard. They were panting for want of fresh air. The poisonous carbonic acid gas increased in quantity every time they breathed, and none of the pure air which was fit for life could get into them. After a very long time one man succeeded in forcing his body

through the tarpaulin: he told the captain that the people below were dying for want of air. The tarpaulin was pulled up, and the captain found the poor creatures lying on one another in heaps. Many were dead and many dying, and only the strongest among them got the fresh air in time to save their lives.

This is a terrible instance of the bad effects of carbonic acid gas. Every day some mischief is done by it; and though people are not often killed in so sudden and awful a manner, a very large number have their health injured and shorten their lives, because they do not know how necessary it is to let the carbonic acid gas escape from their rooms, and to allow the oxygen gas to come into them.

CHAPTER IV.

ON THE CIRCULATION OF THE BLOOD.

I TOLD you that your blood did not remain still in your body. Put your finger on your wrist, you will feel something beating. Do you feel it? That gentle beating is made by the blood travelling through a little pipe. It never stops in its journey. Whenever you put your finger there you may feel the same beating. It might be felt in other parts of your body as well. That is not the only pipe in your body, look at the back of your hand; there, you can plainly

*Fig. 5.**

* View of the palm of the hand and wrist, with the place of the radial artery marked.

see other pipes, called veins. There are two sets of pipes in the body: they have two different names, and are for two different purposes. One set of pipes is for carrying the good healthy blood into every part of the body. You have heard that the blood is purified by oxygen gas, which comes to it through the thin skin of the cells of the lungs. The pipes which carry the healthy blood about the body are called arteries. They branch out into a net-work of the very narrowest pipes, so narrow that they are called capillaries, from *capillaris*, like a hair. The good blood passes through the arteries and capillaries, and then gets into the second set of pipes. The second set of pipes are called veins. When the blood gets into the veins it has to be carried back to the lungs, that it may again be purified.

Fig. 6.*

* Back of the hand, showing the veins.

Now, remember that the pipes called arteries carry good blood to every part of the body, and that the pipes called veins carry the blood which has become impure back again to the lungs.

And in this way God has so wonderfully contrived that the good and the bad blood shall not be mixed.

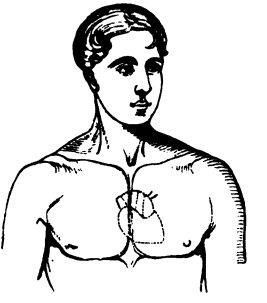
To understand how it is that the blood becomes impure, you must know that the whole body is in a constant state of change. New particles are always being added to every part of our bodies, and old particles carried away. The arterial blood carries the new particles into the capillaries. As it flows through the capillaries it leaves these new particles for the repair and growth of every part. It thus loses its purity and strength. As it flows on into the veins, it carries with it the old particles, which

Fig. 7.*

* Diagram of arteries ending in a net-work of capillaries.

are of no more service to the body. The old particles or waste-matter of the body must be got rid of. There are various ways of carrying it off. It is composed chiefly of one substance, called carbon.

Fig. 8.*



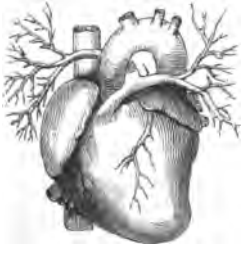
This substance when combined with oxygen gas makes carbonic acid gas. At every breath some part of the waste matter of our bodies is thrown off by the lungs in the form of carbonic acid gas. Other particles of the waste matter are removed by

* Diagram of head and chest, with the situation of the heart marked.

the liver, others by the kidneys, and others by the skin. The machine in which the blood is constantly pumped from the lungs into the arteries, and from the veins into the lungs, is called the heart.

Put your hand on your heart. You feel a stronger beating there than at the wrist. Here is the picture of a heart. All the pipes called arteries are filled from one large pipe, which goes direct from the heart, called the aorta. You will be able to trace in the picture (fig. 10) the contrivances by which the two kinds of blood are kept distinct.

Fig. 9.*

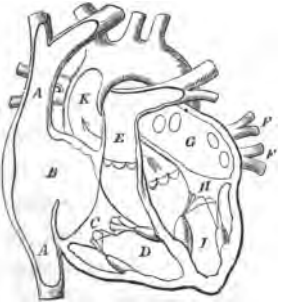


The impure blood has got as far as those two veins marked A A. It then flows into a hole in the heart, called the right auricle (B) and fills that hole. The right auricle

* Drawing of the heart.

has a door (C), which only opens one way. When the right auricle is full of blood it pushes the door open. The door leads to another hole larger than the auricle, called the right ventricle (D). The ventricle, when filled with blood, contracts

Fig. 10.*



and forces the dark impure blood through an artery (E) into the lungs. The blood then flows all round and about the cells of the lungs, in the capillaries or hair-like vessels, and when it has been reddened and purified, it comes back to the left side of

* Diagram of the heart and blood-vessels.

the heart by the two left veins (F F). The blood flows from these veins into the left auricle (G) and fills that hole. The left auricle has a door (H), which only opens one way. When the left auricle is full the blood pushes the door open. The door leads to the other hole called the left ventricle (I). This ventricle, when filled, contracts, and forces the pure blood into the pipe called the aorta (K), and from the aorta into all the arteries of the body. It passes from thence into the capillaries; from them into the veins, and so back to the heart again.

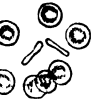
The pushing open of the doors or flood-gates, first on one side and then on the other side of the heart, and the contraction of both the ventricles, makes a kind of pumping, which may be heard, and a beating which may be felt. This movement of the blood through the body is called the circulation of the blood. It goes on very quickly. The flood-gates of the heart are opened and shut at least seventy times every minute.

CHAPTER V.

ON THE BLOOD.

When you prick your finger, and the blood comes out, it looks to you like a red fluid: but it is not so really. The blood is a white fluid, very much like water, with very small red cells floating in it. The cells are hollow and flat. We cannot see them with our naked eye, but they may be seen in a microscope, because the glasses of a microscope enlarge what we look at through them. The flat hollow cells which float about in the watery fluid are not always bright red. They are only bright red when they contain much oxygen gas. Here is a picture of the cells in the blood.

Fig. 11.*



* Blood-cells.

These little cells carry their cargo of oxygen gas along the pipes called arteries.

The arteries may be compared to trees, supposing all the branches were hollow. The trunk is the aorta, that large pipe opening from the heart. From this trunk there are branches, and from the main branches very much smaller branches, like the twigs of a tree, and from the pipes resembling twigs a fine net-work of hair-like pipes, formed like the frame of a leaf. Have you ever seen a skeleton leaf? a leaf from which insects have eaten away all but the fibres. Here is a picture of one. Those fibres that are left are like the net-work of the arteries and capillaries. All the hair-like pipes, or capillaries, are hollow; and the watery fluid, and the little flat hollow cells float through them. As the little cells float along from the aorta to the

Fig. 12.*

* Diagram of the skeleton of a leaf.

capillary vessels, they gradually part with their cargo of oxygen gas, and take in another gas instead. The greater part of the materials of our body consists of carbon. Now when oxygen gas meets with carbon, it combines with it, and forms carbonic acid gas. Much of the old particles of our bodies being made of carbon, the throwing off this gas by our lungs when we breathe, removes a large portion of waste matter. You have already heard so much about this gas that you will remember that it is a poisonous gas not good for life.

Oxygen gas and carbon then unite in the body, and a new gas is made. When two bodies are combined to make a new gas, while the change goes on warmth is produced. The comfortable feeling of warmth which we have in our body, is from the making of carbonic acid gas in it. So you see that though the carbonic acid gas is poisonous, there is great use in having it made all over us. The body is warmer and more

healthy when the gas-making goes on quickly in it, and when the blood is pumped actively. Exercise is, therefore, useful; we are warmer after walking than when we have not walked. Jumping and running make us warmer still. This is because the floating cells are carried along the pipes more quickly when the body is exercised, and the new gas is made more rapidly. When the cells are filled with the new gas, which is made in the body, they are no longer bright red: the blood then does not look scarlet. It changes to a dark purple colour. Look at the veins in the back of your hands. Those veins, which carry back the little cells loaded with their new cargo, look blue from the altered colour of the cells. The cells loaded with carbonic acid gas get to the lungs in the manner you read of in the last chapter, and the carbonic acid gas they have in them comes out of our mouths every time we breathe. In the Bible the blood is called "the life." Those little flat hollow cells in the blood

carry the gas which supports life. If they ceased to take their load of oxygen gas constantly through the arteries into every part of the body, there would be no life in the body, it would die. It is very injurious to the body to take no exercise. The blood should flow quickly, but when persons sit still for a very long time together, they can tell how slowly the blood flows by the coldness of their hands and feet. The chilly feeling that arises from sitting still for a very long time, leads them to dislike the fresh air, which is so necessary. They shut up their windows and doors, and cannot bear air, which would, if they also took exercise, do them good.

CHAPTER VI.

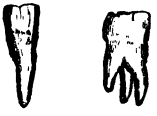
ON FOOD AND DIGESTION.

WHO would think that the variety of food, bread and meat, and the many other things we put every day into our mouths, could be so altered as to make the little cells and watery fluid called blood? this seems impossible. It is a wonder that goes on within us every day, and yet perhaps we have scarcely ever thought of it. We pass over many of the wonderful works of God which He does every day around us and within us, and never think of them at all. When we do think of them and consider them well, we may be sure that, as the Bible says, "all things are possible" to that great Being who is always doing such wonderful works.

When we eat food we first cut it in pieces with the front teeth.

Here is a front tooth. We then grind it with our back teeth. Here is a back tooth. This grinding should be done thoroughly. There is a moisture within our mouths called saliva, or spittle. This is of great use to mix with the food before we swallow it. When the food is ground it goes down the throat, and then we think no more about it. It passes into a bag called the stomach. There is another kind of moisture provided in the stomach different from that in the mouth. It is called the gastric juice. As soon as the food gets into the stomach, this juice which is acid, mixes with it.

Fig. 13.*



Then this curious bag (the stomach) does not remain still; but it can become smaller and then again larger so as to squeeze the food that is in it, and well mix it with the acid. When this is done the food is no longer solid. It is a thick

* Drawing of an incisor tooth and a molar tooth.

fluid. It then passes into a large channel, called the intestines, and there, two other juices are mixed with it, by which it is made thinner still. It is now as thin as milk, and something like milk in appearance. It passes still farther down the channel. And now the food which we took into our mouth, and which has been so much altered by the action of these various juices, is fit to make new blood. The inside of the intestine which contains the milky fluid, is covered with very small projections. They contain vessels which have the power of drawing the milky fluid into them. They are called lacteals (from *lac*, milk).

Fig. 14.*

Like the capillary vessels they branch off into larger, and then again into larger tubes. At last they form a pipe as big as a com-

* 1, Drawing of a lacteal.

mon quill, called the thoracic duct, which opens into the veins near the right side of the heart. The milky fluid, if examined, would be found to contain the same shaped cells as those which are in the red blood. It is indeed blood, not yet coloured by oxygen gas, it has therefore to travel to the heart, from whence it is driven to the lungs for that supply of oxygen gas which we are getting every moment from the air. What a curious net-work is matted together throughout the whole body! How many branching tubes, and for how many various purposes!

There are the lacteals for the new-made blood (when ready for its last component oxygen gas), the arteries to convey it through the body when it is fully made,—the veins to carry it back when impure; and there are yet more than these. The lymphatics begin in a net-work of hair-like vessels in every part of the body. They unite to form larger vessels, just as little streams unite to form a river.

The larger vessels pass through glands, and becoming still wider and fewer, open into the thoracic duct which carries the prepared food into the blood. A whitish fluid, called lymph, flows through the lymphatics. The use of the glands, through which they pass, is to prepare the lymph into materials for blood; for though part of the lymph is useless, and passes away as waste matter, a portion of it is used again for fresh blood, when it has been acted on in the glands and in the lungs. When the glands are out of order they swell; they may then be felt in some places through the skin. Those at the neck sometimes feel like little hard lumps.

It is very necessary for the health that the lymph should flow on without interruption till it reaches the heart. If the passages through which the lymph flows are clogged up, it is interrupted in its course, and the part swells to an unnatural size.

The words "waste matter," have been

frequently used in explaining the changes in the human body, by which a part of it is continually thrown off. These words are convenient in describing such a process. But they must not be understood to mean that any part which has finished its work in the human body is rendered useless. Every little particle in God's creation is of use. When it has served one purpose it immediately fills another where it is wanted.

The carbonic acid gas breathed out in such large quantities by human beings and animals, is necessary to support the life of plants.

Even while the "waste matter" is passing from the body in the form of gas, it is serving a purpose without which we could not live, for as you have heard, the combination of oxygen gas with carbon is the process by which we are warmed. All the furs and flannels we could put on, would do nothing to warm us if we were not warmed by the formation of gas within

us. The food that we eat is also our fuel. Clothing only serves the purpose of preventing the warmth from within from flying off too fast.

CHAPTER VII.

ON THE NERVES.

THERE are still many more contrivances in our bodies that we have not yet thought about.

Fig. 15.*

How is it that we can feel, taste, smell, hear, and see? We have quite another set of tubes for these purposes. They are fine narrow tubes, very much finer than hairs if examined in a microscope, but as there are a great many together, they look like white threads and cords, which are easily seen when the skin is removed. Here is a drawing of the arm, with the skin off, showing

* Nerves of the arm.

the nerves. They go to every part of our body, from our brain and spinal marrow. The brain is in the head, and the spinal marrow is joined to it, and goes down the back. Here it is; and here are also some of the nerves. They pass from the brain and spinal marrow to every part of the body. They may be compared to the wires of an electric telegraph. Did you ever see such wires? if you have not seen them I dare say you have heard about them. They are passed from one town to another, and by the electricity which passes along them, the motion of a handle at one end of the wires, will instantly ring a little bell attached to the other end of the wires, a hundred miles off and more. Another motion of the handle at one end of the wires, perhaps in London, will move a hand, like the hands

Fig. 16.*

* Drawing of brain and spinal marrow, with nerves.

on a clock, at the other end in Edinburgh, or Liverpool, or Southampton, and by this means messages can be delivered from one place to another instantly, though they are parted by a distance of so many miles. A man sits in the room at one end of the electric telegraph to work the handle, and there is also a man in a room at the other end to observe the movements of the hand, that he may know what message is delivered. The wires of an electric telegraph might be placed from one town to another all over England, and if there were not people in the little rooms to work them, they would be of no use, they could not carry messages of themselves. Who works the wires or nerves in our bodies? They are laid down from the brain, and from the spinal marrow, which communicates with the brain, all over the body. How can they be worked?

Who is there that can get into that small room, the head, and sit in the brain and work the wires? It is your spirit which

sits there, and sends its orders along the lines or nerves to every part of the body. If the spirit were gone out of your body, the nerves would remain there, but they would be quite still, and of no more use. When the piano is shut, and no one is playing on it, it has its notes and wires just as complete as when a person sits down and strikes the notes and puts the wires in motion.

The spirit lives in the brain as long as it pleases God, and when He calls it away, the body, which may be compared to an instrument, on which it has played, is no longer of any use. But the spirit is living still. It has left the body, and the body when left without it, will soon fall to pieces, but the soul is not in the least injured by what happens to the body, any more than the man who sits to work the electric telegraph would be injured if the wires of the telegraph were broken.

There are two sets of nerves; they are called the nerves of sensation and the nerves

of motion. One set of nerves carries messages from the outside of the body to the brain: these are called nerves of sensation. The other set of nerves carries messages from the brain to the various parts of the body: these are called nerves of motion. If I touch you, a nerve of sensation carries the feeling to the spirit in your brain. The nerves of sensation from the eyes to the brain inform the spirit there, of all that your eyes can see. The nerves of sensation in the ears acquaint the spirit in the brain with all pleasant or discordant sounds which strike the ends of the nerves in the ears. The nerves of sensation in the mouth inform the spirit in the brain of all the sweet or sour, the nice and nasty, tastes, of what you eat and drink. The spirit in the brain has to receive all its learning by means of the nerves.

All the lessons you study are carried along the nerves to the brain. The brain is a much better instrument in some people than in others. People (as you know) are

differently made. Their faces and bodies are different from one another.

Their brains are also different, and if the spirit within has a weak brain to work upon, it is like our having an imperfect instrument to play. It cannot work the nerves with the same success.

The other set of nerves are the nerves of motion.

These are for the use of our spirit whenever it wishes to move. It is a very active being that lives within us; it has many wishes. It all day long has some work for its electric telegraph. When you write, the nerves of motion from the brain to the right arm move the muscles so as to make the various forms of letters just as the spirit commands. Sometimes the spirit sends its orders that the feet shall move in walking, skipping, jumping, or dancing; sometimes that the hands shall sew, or hem, or stitch; sometimes that the mouth and throat shall sing, or that they shall talk, or eat, or drink. The spirit within often desires that

the instrument shall do all its work better. It sometimes makes it do its work again and again; and every time the nerves work willingly to do anything, they become more able to do it well.

CHAPTER VIII.

LAURA BRIDGMAN.

LAURA BRIDGMAN was born at Hanover, in New Hampshire, one of the United States of America, December 21st, 1829. She was a pretty, lively, blue-eyed baby, but not very healthy, for she had sometimes severe fits, which shook her little frame violently. When rather more than a year and a half old her fits left her, and she became quite healthy. She showed as much intelligence as was possible for one so young, and got on quickly in the use of her limbs, and all her senses. But in four months the poor child was attacked by a dangerous fever, and lay in her little bed, tossing in pain and distress, for seven weeks.

The disease destroyed her sight, her hearing, her smell, and her taste. For a year

she was so weak that she could not walk alone, and another year passed before she could sit up all day. By the time she was four years old, her bodily health was restored; but what a helpless little being she had become. How different from the intelligent lively child who lay down on the bed of sickness. How was she to learn any thing with no sense left but that of feeling? Her poor mother could not tell. She loved, however, to have little Laura near her; and the blind and dumb child knew her mother, and followed her everywhere. She exercised the only sense she had with great activity. She would feel the weight of different things, and observe their different qualities of smoothness, roughness, &c. She felt her way about the house, and when her mother employed herself in various household duties, the child felt her arms and hands, and tried to imitate the movements of them. She even learnt to knit by feeling her mother's fingers, and thus learning the proper movement of them.

An American physician, Dr. Howe, heard of this little girl. He had an asylum for the blind at Boston, in which they were taught to read and work. He came to Hanover to see Laura Bridgman, and he persuaded her mother to let him take her to the Blind Asylum, for he believed that she might be taught many things which would make life happy to her. The mother consented, and the little girl was carried away to Boston, on the 4th of October, 1837. She seemed bewildered for a time by being in a new place, and having so many people about her, yet she learnt shortly to find her way about the house, and to distinguish one person from another in it. She made use of a few signs by which she could acquaint others with her chief wants. Her teacher did not intend that she should continue the use of these. He meant to instruct her to talk with her fingers, as the children who are deaf and dumb do. He meant also to teach her to read: the blind are taught to read by raised

characters. The letters are embossed on cards or paper, and they feel the various shapes of them. When they have felt the letters, they are told the proper sound belonging to them, and then are made to pronounce the syllables and words made by the combined letters. But when little Laura had distinguished the different forms of letters by her touch, how could she be informed what they meant? She could hear nothing!

Happily she had fallen into the hands of teachers who were ingenious, patient, and loving.

Various articles in the house — keys, spoons, knives, books, &c., were brought before her. A label was pasted to each article, on which its name was embossed in raised letters.

She felt the letters k e y and s p o o n, and could observe that the forms were different. She also observed that the key was different in shape from the spoon.

Then the labels were given her apart from

the articles, and she very soon learnt to place the labels rightly on the articles to which they belonged. Her teacher all this time could not be sure that she had learnt more intelligently than a dog or a parrot, who may be taught clever tricks. One day, when the usual process was going on of feeling new labels, and learning to what articles they belonged, her teacher saw a look of bright joy on the little girl's face. It seemed that she had suddenly discovered that this process was not like the knitting her mother had taught her, a mere employment for her fingers, but that the crooked embossed letters were signs by which she could make known to other minds what was passing in her own.

After this she learnt eagerly and willingly. The letters were all cut apart, and she soon could distinguish each letter by its shape, and could pick out and put together those that spelt the words she had been taught.

Metal types, on which the letters of the

alphabet were embossed, were then given to her, and a board in which were rows of deep square holes. In these the types could be placed, so as to leave only the embossed letter above the surface.

She was now very frequently, and for a long period, exercised in putting together words on her board. A pencil, or watch, or other article was handed to her. She selected the letters making up the word pencil, watch, &c., and placed them in order in her board.

She was next taught how to represent letters on her fingers, and she speedily learnt the finger-alphabet, used by deaf-mutes, and then all the words which she had been taught to spell with her types. She wished to know the name of everything she could touch. When taught anything new, she held her head as if listening intently, and scarcely seemed to breathe. If she could not understand, her countenance looked anxious, but it changed to a look of pleasure the moment she comprehended

what was taught her. Laura was as happy and playful as if she had not been so afflicted; she never repined. Sometimes she was busy for hours sewing or knitting: her mind seemed constantly at work. She would count with her fingers, or spell the names of things on them. She would spell a word wrong with her right hand, and then strike it with her left in play; and when she was correct in her spelling, would pat herself on her head, as her teacher was accustomed to do, to show approbation. She became very fond of her playmates, and liked always that one or other of them should be near her, and it was observed that she preferred those who were most intelligent, and showed a rather unamiable contempt for stupid children. She was able to understand conversation on the fingers by passing her fingers over the hand of the person with whom she was conversing.

After she had been some time in the Asylum, her mother came to see her.

Little Laura was playing with the other children, and of course did not know that a visitor had come into the room. She was led up to her mother, but shrunk away, thinking it was a stranger. Her poor mother, distressed not to be recognised by her child, put into her hands a string of beads, which she had worn when at home. Laura took them, put them on with joy, and then signed with her fingers that she knew these had been sent to her from home. But still she shrunk from her mother. Something else from home was then given her. Laura by this time had found out that the stranger must be a visitor from Hanover.

She drew nearer, seemed to have some vague idea of who it was, turned very pale, and then reddened,—looked as if in painful uncertainty, and when her mother drew her to her, and kissed her fondly, Laura clung to her, and nestled into her bosom. It was evident that the memory of her earliest childhood had returned to

her. She did not want the beads now; she cared for nothing else but to be by her mother.

Laura had been trained to entire obedience to her teacher. When, therefore, her teacher directed her to come away from her mother, she obeyed, though with evident reluctance, and she sprang eagerly again into her arms when she was allowed to do so. When her mother was obliged to leave, the little girl wept bitterly; and, afterwards, if ever she fancied those about her were cool to her, or did not notice her so much as usual, she would say on her fingers, "My mother will love me." A traveller in America, who has given the account of Laura Bridgman, from which the materials for this story are taken,* says, when he visited the Asylum and saw her, her face was radiant with intelligence and pleasure. Her dress was neat and simple, and was arranged by herself. Some knitting done by herself lay beside her.

* C. Dickens.

She had a writing-book before her, and in this she wrote a diary in a clear hand. She liked to play with a doll. All the blind children had a ribbon bound round their eyes, and she had put a piece of ribbon round her doll's eyes.

Her teacher one day found her acting as if her doll was sick, giving it medicine and putting a hot bottle to its feet; and, on proposing that a blister should be put to the doll's back, little Laura clapped her hands for joy.

This story of Laura Bridgman shows how much may be learned with only one sense, if the mind is awake and attentive. It would be well if all who have five senses were to use them as diligently as Laura used her one sense. She acquired all her knowledge by attending to, and thinking about, what she touched. We may learn very rapidly if we pay great attention to, and think about all we see, hear, touch, taste, and smell.

CHAPTER IX.

ON THE BONES.

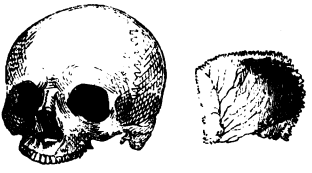
Our body would fall together and have no stiffness in it, if it had not a frame to which all the various parts of it are fastened.

The frame of our body is made of bones.

If this frame were quite stiff we should never be able to bend or move. It is put together with a great many curiously-contrived joinings and hinges. At the very top of the frame there is a box. You have seen the picture of the brain. The brain is so soft and delicate that it needs the greatest care. A blow would injure it, and any pressure on it would prevent the spirit from directing the nerves properly. It is therefore placed inside a box, called the skull. The bones of the skull are

extremely hard, so that only very great violence would break them. This box is in several pieces. In this picture you can see that the edges of the bones are like saws—the notches fit into each other.

Fig. 17.*



There are small holes in the skull, through which the nerves pass. The skull is supported on a column of bones, called altogether the back-bone or spine. This column is made of twenty-four bones; they are placed one on the top of the other. The bottom of one fits exactly to the top of the next.

The uppermost bone of all is fixed to the skull by a hinge. Nod your head. Now you use that hinge.

* Drawing of a skull and one of its side bones.

But a hinge of this sort is only useful for one movement, and the head has more than one movement. You can turn it from side to side. If you had but that hinge, whenever you wished to look to the right or left, you must turn your whole body. The second of the twenty-four bones has, therefore, a different joint. There is a point something like a tooth rising from the second bone. This tooth fits into a notch in the first bone, and is a pivot on which the head is turned from one side to the other. Below the two hinges the bones go on fitting into each other, and they have between them thick gristle. You know that gristle is easily bent. The bones give stiffness to the spine, the gristle enables it to bend, and thus it is fit for its two purposes; to support the head and

Fig. 18.*

* Skull and spine.

the body, and to enable the body to throw itself into various positions with ease.

If you look back to the picture of the brain, you will see that the spinal marrow is attached to it. The spinal marrow is contained in the spine. All the bones of the spine are hollow, so as to allow room for it; and they protect it, as the skull protects the brain. For the spinal marrow is of the same tender and delicate substance as the brain, and it therefore needs to be well covered. The nerves pass from the spinal marrow as well as from the brain. Where the bones are fitted together little openings are left, for the nerves to pass out.

Each of the twenty-four bones has two notches above and two below, and in placing the bones one on another, the notches meet, and thus small holes are left.

The twenty-four bones are strongly hooked together, so that whichever way the body bends they cannot be jerked out of their places.

It is useful to the whole body that it should be well exercised, and it is also much more convenient to bend many ways, than it would be to be always stiff.

We can tell the flexibility or power of bending that the back has, by the wonderful performances of tumblers and rope-dancers.

CHAPTER X.

ON THE BONES (*continued*).

THE rib-bones are joined to the back-bone. The ribs are a frame of bones which enclose a hollow space. The lungs and heart are within them. The ribs are fastened in front to a bone called the breast-bone. Here is a picture of the ribs behind and in front.

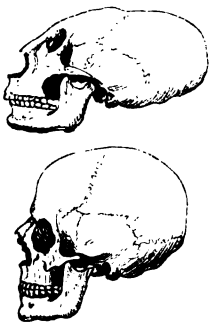
Fig. 19.*

In front the rib-bones are joined to the breast-bone by gristle, and this gives them some flexibility, and enables them to move more easily when the lungs fill with air. If you take a deep breath you can feel how much the ribs move. It is very ne-

* Ribs—front and back view.

cessary to health that this movement should go on easily at all times. If anything prevents it, the lungs and other parts of the body become unhealthy. You have heard how tender the brain is, and how bad any pressure is for it. There are people in some parts of the world, who, when the bones of young children's skulls are soft and tender, bind them up to flatten them, thinking that a flat skull of this shape is beautiful.

Fig. 20.*



"A singular custom (says an American) prevails among most of the tribes about this part of the coast (the west of North America), which is the flattening of the forehead. The process by which this deformity is effected commences

* Flattened skull of a Carib compared with a natural English skull.

immediately after birth. The infant is laid in a wooden trough, by way of cradle. The end on which the head reposes is higher than the rest.

"A padding is placed on the forehead of the infant, with a piece of bark above it, and is pressed down by cords, which pass through holes on each side of the trough. As the tightening of the padding and the pressing of the head to the board is gradual, the process is said not to be attended by much pain.

"The appearance of the infant, however, while in this state of compression, is hideous, and 'its little black eyes,' we are told, 'being forced out by the tightness of the bandages, resemble those of a mouse choked in a trap.'"*

Besides these people, who are called by some "flat-heads," there is another nation who bind the delicate bones of the feet of their young female children, so as to prevent their growth, and lame them for

* From Washington Irving's "Astoria."

life, because they think they can make the foot of a better shape than He who made the body. There are other people who

Fig. 21.*

will not allow the frame of the ribs to remain as the Maker has intended. They make another frame into which they fasten steel or wooden bars, and bones of the whale, and they fasten this frame round the frame of the ribs. It does not give pain, but it hinders the free movement of the lungs. It is not difficult to press the ribs into a smaller space than they ought to have; those ends of gristle which join them to the breast-bone, may be pressed in with more ease than if the whole substance of the ribs was bone.

* Chinese woman's foot.

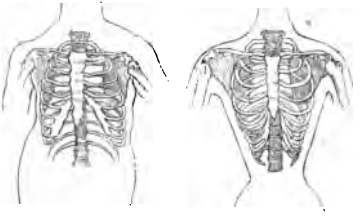
The body having an artificial frame, soon gets accustomed to rest on the steel or wooden bar, which is placed perpendicularly in front.

The body ought to rest on the pillar of the back-bone, which is intended for its support.

The stooping posture, which is comfortable when there is something to rest on in front, is injurious to the lungs. You will have found out that the frames, about which I have been talking, are called stays. Stay is another word for support. It is a mistake to fancy that the healthy body needs any other support than that which God has given it. But stays are not only worn for support; they are also worn for the very same reason that some tribes of American Indians flatten the skulls of their children, for the same reason that the Chinese cramp the infant's foot. It has been considered an improvement to the shape of the body to have it small: where if left to itself it would be larger. Here

is a picture of the shape of the ribs as they ought to be; and here they are, in that shape into which they are brought by the pressure of stays.

Fig. 22.*



These frames having become a customary part of dress, many persons wear them, merely because it is the custom. They do not occasion them any pain, for the pressure has been so gradual that the gristly part of the bone has easily yielded to it. It would occasion much discomfort to a person long used to stays, to leave them off. Yet these comfortable supports injure the health of all women who have not *very*

* Natural and distorted ribs.

strong bodies. When the lungs, &c., have not proper room, the air that is breathed and the food that is ate, does not do so much good as it otherwise would.

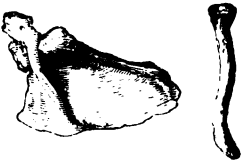
Many persons are languid, have frequent head-aches, poor appetites, a bad digestion, owing to the unnatural pressure round their bodies.

CHAPTER XI.

ON THE BONES (*continued*).

JUST below your neck you can feel two bones, called the collar-bones. They are fastened to the top of the breast-bone. They

Fig. 23.*



reach to the shoulder-blades, and are joined to them. You can feel your shoulder-blades. They are large bones on each side of the back-bone. The end of each shoulder-blade is in the form of a cup. It is made very

* Collar-bone and shoulder-blade.

smooth by a covering of gristle, for the surface of this gristle is as even as the finest ivory. So that the cup is very smooth and very highly polished. The arm-bone, which fits into it, ends in the form of a ball, as smoothly polished as the cup. It can move round in the cup with the greatest ease. It would slip out of the cup altogether, but for a cord, which fixes it into its proper place, and yet allows it to move freely round. There is a strong skin also, attached to the edge of the cup, and tied down over the ball. Move your arm round and round at the shoulder. You will then use this ball and socket joint. Have you watched a man turning a grind-stone? He uses this joint all the time he turns it. When you skip with the skipping-rope you use this joint. The beautiful polish in the cup and ball is kept up by a

Fig. 24.*

* Shoulder-joint and shoulder-blade.

good supply of oil. You know that if we have a rusty lock we oil it to make it turn easily. Have you ever noticed when the carriages on a railway stop, men take buckets with an oily mixture in them, and put the grease into the boxes of the wheels, to make them turn smoothly.

We could not get at our joints to oil them if they became rusty and creaked. But God has provided an oil for the joints which is always ready to keep up the beautiful polish, which enables the ball to roll smoothly in the socket, and the hinge to work well. This oil oozes from a fine skin, which lines the greater part of the joints. When you have been running very fast on a warm day, very small drops of water come out on your skin, so that it is made damp. This is called perspiration. The oil comes out from the skin, lining the joints in just such little drops and keeps them smooth.

At the elbow there is a hinge-joint; the end of the upper bone of the arm projects

as you see in the picture, and it fits into a deep notch in the lower bone of the arm. The arm from the elbow to the wrist is called the fore-arm. It is made of two bones, one of them has the notch which forms the hinge-joint. Have you seen a carpenter hammering? All the time he hammers he uses the hinge-joint at his elbow. The elbow-joint only moves backwards and forwards like a door-hinge. The wrist can move backwards and forwards like the elbow. You can turn the palm of your hand upwards and downwards. This could not be done by a hinge-joint. The second bone of the fore-arm works in a socket at the elbow. It is by this socket that you can turn the palm of your hand up and down.

Fig. 25.*

* Bones of the arm and hand.

All the fingers have simple hinge-joints. There are several little bones at the wrist which serve to strengthen it without making it too stiff to move easily.

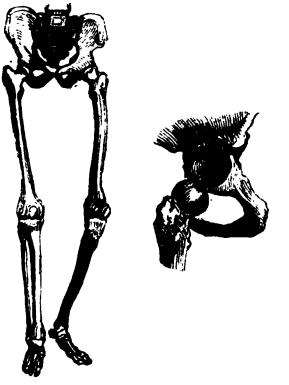
CHAPTER XII.

ON THE BONES (*continued*).

WE have now traced the principal bones of the upper part of the body: we have still the lower bones to examine. How useful are the legs and feet to every other part of the body. Unless these bones were well used, all the body would be weak. They must walk, and dance, and skip, that the blood may flow quickly, and they must carry the rest of the frame into pure, fresh air, away from the smoke of towns, that the lungs may have a good supply of the proper gas for life. The bones of the leg and foot are made so strong that they can bear very frequent use, and so light, that they can be accustomed to a great variety of movements. At the lower part of the back-bone there is a large basin

made of bone, and to this is fixed the upper bone of the leg. It has a ball and socket-joint like the shoulder-joint, and also like it a round cord passing from the centre of the ball to the centre of the socket, and

Fig. 26.*



whilst fixing the bone in its place, yet allowing it to move freely round; as is shown in the picture.

The knee has only a hinge for moving

* Pelvis with lower extremities. Hip-joint with round ligament.

backwards and forwards. It is fitted and polished and oiled like the other hinge-joints, but it has something over it which no other joint has. There is a thick bone fitting over it, called the knee-pan.

The knee-pan is a shield for the knee-joint. It wards off blows, and protects the joint from being injured by a fall. Children, when they run very fast, often fall forwards on their knees; it is well they have their little shields on, or their legs might be made lame for life. From the knee to the ankle there are two bones; they end in two knobs, which you can feel. Between these two projecting ends the upper bone of the foot is fixed. Here is the foot. The uppermost bone of the foot works between the ankle-bones as a hinge. There is no need to turn up the sole of the foot as we turn up the palm of the hand.

Fig. 27.*

* Ankle-joint and foot.

It has, therefore, simply a hinge. The instep is formed of several small bones, placed together in the form of an arch; they make the foot strong. One thick lump of bone would have made it strong. But there is another purpose in this arch of small bones.

They enable the foot to move with a

Fig. 28.*

spring. Each bone gives way a little when

* A dancer bounding.

the foot moves, and thus it can bound and dance in such a way as would have been impossible if there had been but one lump of bone. We use all our limbs so much less than we might use them, that we often do not think what a wonderful power our body has. A professed dancer shows what strength and lightness and springiness there are in the legs and feet. See how she bounds. The toes have hinge-joints like the fingers. We make very little use of these hinges; but the savage inhabitants of one part of Australia find them almost as useful as hands. They walk into streams and catch fish with their toes. The Australian savage thinks himself a much greater man than the traveller whose feet are so cased in boots, that he has never attempted to use them for any other purpose than walking. But the traveller might make him wonder, for while the savage has been so active with his feet, he has used his brain, and can do things which would make the poor ignorant savage think him a magician.

CHAPTER XIII.

ON THE MUSCLES.

ALL the bones of the body, with their various joints (which we have been speaking of), are covered with flesh; the flesh is called muscle. The muscles of our body clothe our bones. Each end of a muscle is firmly fastened to the bone. The muscles are made in so wonderful a way, that they alter in size so as to become shorter or longer with every motion of the body. Keep your arm still by your side. Now raise it up, and stretch it out behind you. As you do this, the muscle at the shoulder shrinks at both ends, so as to become shorter. But if you put

*Fig. 29.**

* Muscles of the arm, the skin removed.

your arm again still by your side, the muscle has again lengthened to the same size that it was before you stretched out your arm.

If the muscles are much used they increase in size; if they are not used, they become smaller and dwindle away. A

Fig. 30.*

sailor, who toils with the arms and the upper part of his body in managing the

* Sketch of a sailor, showing the breadth of his shoulders and the narrowness of his hips.

rigging of a ship, or in rowing boats, becomes strong and large in the arms and chest. The muscles of the upper part of the body, increase in size, from the constant exercise he gives them. His legs are small in proportion to the arms and chest, for he has less exercise for their muscles while at sea. In some countries men are trained to run swiftly, that they may carry news from place to place. The muscles of their legs grow large. The muscles of the calf of the leg become very large in those that dance much.

A well-shaped body has all its muscles in good proportion. The ancient Greeks were a very skilful and intelligent people. They surpassed all other nations as sculptors. One reason that they did this was, that the form of the body of the Grecian men and women was more beautiful than that of other people. The Grecian men practised athletic exercises. They climbed, and ran, and threw heavy weights. The bodily exercises now sometimes taught to

English boys and girls, are copied from the Grecian exercises, and have names derived from the Greek. The Grecian woman never wore that frame of whalebone and steel which the Englishwoman wears. She had flowing robes, which hung gracefully over her. She never became crooked as so many English girls become. One shoulder did not stick up higher than the other. Her waist was large enough to allow free play to her lungs.

There are a number of muscles attached to the back-bone. The back-bone is (as you have read) a chain of bones, so contrived as to be very firm and yet very supple or moveable. The muscles are to assist its motion. As you walk, the back-bone should be the support of the body.

In sitting upright, and walking in an upright posture, these muscles are used. They are made strong, like the other muscles, by exercise. But if the body leans for support on stays, the muscles of the back, from being little used, become small

and weak. They then no longer keep the chain of bones in its right place; the chain curves, and the body becomes crooked.

Fig. 31.*

Here is the picture of a back which has become crooked. Why did this back lose the power of its muscles, and get this sad curve? It was because people were trying to make the young lady upright in quite a wrong way. She should have been made upright by using the muscles of her back. But ever since she was a little child, her friends laced her up so tightly that she has not been able to use those muscles freely. They did not intend to injure her. They loved her, and thought they should make her very upright. Poor thing! She might have been healthy and useful. Now she will have to lie on her back, and to be nursed and waited upon. She will suffer very much, not because her

* Back, with lateral curvature of the spine.

friends meant to injure her; they did not know what they were about. If they had made her march about with a weight upon her head, leaving her clothes quite loosely round her, they would have strengthened the muscles of the back. I am afraid she never will be strong, but others can take warning from her case, and make their children take such exercise as shall strengthen all the muscles of the body.

English boys are better used in this respect than English girls. They have no stays, and they play at cricket, and at many other useful games. It is very seldom therefore, that boys have their back-bones curved, while girls are very frequently thus deformed.

CHAPTER XIV.

ON THE MUSCLES (*continued*).

THERE are two sets of muscles in the body. One set of the muscles is employed at their work of moving the body whether we wish it or not. Whether we sleep or wake, whatever we are doing, or whatever we are thinking of, these muscles go steadily on with the work given them to do. He who made the body, and who keeps it alive every moment, commands these muscles to do their work; they do it until He says they shall do it no longer, and then they are still and we die. These muscles, which are under the control of God, but which are not under our own control, are called involuntary muscles. If we are in health we scarcely think of the work that they are always doing, because

we do not even feel it. We do not feel the churning of our food in the squeezing bag or stomach, or the pouring out of the various juices to mix with it; nor do we feel when the food, after being turned into a liquid, is taken up by the lacteals and passes into the veins. Neither do we notice the perpetual pumping of our hearts unless something is wrong. When all is not going on well within us we can feel what we call pain. This feeling is then useful, for it gives warning that something must be done that the involuntary muscles may again work easily. How can we get at our involuntary muscles? We can get at them by means of our voluntary muscles. This is the name of the other set of muscles; we work them by our own will. Our own selves, that part of us which we cannot see, that spirit of ours which has its seat in the brain, is always, while we live, ready to work our voluntary muscles. Look back to the Chapter about the Nerves if you do not quite remember it, and there read

again what our spirit does through the nerves. It is through the nerves that the spirit within us moves the voluntary muscles, and both nerves and muscles are all over the body. Just think how wonderful it is that an order from the brain, given by the invisible spirit there, should command the muscle to shrink back, and that it should instantly obey. The power that the muscles have to become shorter, by shrinking up, is called contractility.

If you take a piece of Indian-rubber, and pull it out with both hands and then let it go, it shrinks back. But the spirit within you has but to send its command or its wish along the nerve to the muscle, and the muscle instantly shrinks without being first stretched out: this is very wonderful. It is so with all the works of the Great God; we can know but little about them. He is pleased when we learn as much as we can about them, that we may more humbly adore Him, for, as the Scripture says, His ways are past finding out.

All that we do by intending it, and by wishing it, is done, then, by our voluntary muscles. We walk, run, write, speak, put our food into our mouths, bite it, swallow it, all by our voluntary muscles. We wish and intend to do these things, and the muscles obey our will.

CHAPTER XV.

ON THE SKIN.

EVERY part of the body that we have been speaking of is covered up. What is it that wraps over all? We call it skin. We might call our covering skins, as there are two kinds of skin, one over the other. The outer skin (called the *epidermis*, or scarf-skin) is a protection to the under skin. It is made of a very great number of the smallest scales, and these scales are continually coming off, and fresh ones are placed in their stead. There is no feeling at all in the outer skin. But, you will say, if I touch my outer skin I feel the touch directly. That is true. There is so much sensation in the under skin, that if it were not protected by those little scales that form the outer skin, every time we

were touched we should feel pain. The little scales of the outer skin are placed over the under skin, that every touch may not give us pain. When you burn your finger, so as to raise a blister on it, you may see the outer skin separated from the under, and raised up. If you were to prick the raised skin without touching the part below, you would feel nothing. But if the outer skin comes off and leaves only the under skin, the slightest touch on the under skin would make you shrink, it would be so painful. For the under skin is made up of numberless fibres, and of the net-work of veins and arteries, and close beside every one of these vessels are the ends of the nerves forming also a net-work. The spaces between the net-work are filled with innumerable little bags. These minute bags (which are called glands) have openings which should not be choked up by the outer skin. If the scales of the outer skin close the holes of the glands, it is very bad for us.

What is the use then of these small bags? They hold a moisture which comes out of the blood, and which ought to escape from their openings and fly off from us into the air. If the moisture cannot get away —if the opening through which it ought to go is stopped up by the little scales, then it gets back into the blood and injures our health. The scales of the outer skin do not come off very easily, they need to be rubbed off.

It is best for the health of the body that the arms and legs, and the whole body, should be much exercised. When a man is employed in hard labour, in digging, sawing, planing, &c., the various parts of his body are rubbed one against another, and against his clothing: the scales then come off, and the moisture comes out as it should do. But when persons sit very much, and when a gentle walk is their only exercise, the scales are not worked off so quickly as they should be.

There is, however, a way of working off

the scales which is very useful to those persons who can only lead a quiet life. This is by washing. The body should be washed all over once in twenty-four hours; and it should also be well rubbed with coarse towels. The moisture can then pass through the ends of the glands. The moisture that is at all times passing off from our bodies is called *insensible* perspiration, because we cannot feel or see it. When there is no feeling of dampness on the skin, the insensible perspiration still flies off. Lay your hand (when it feels dry) on a looking-glass; when you have held it there for a short time, you will see a mark on the glass like that made by steam. That is the insensible perspiration. If you run very fast on a warm day, or labour in the garden digging and weeding, the moisture which comes out of the glands of the lower skin can be seen and felt. It is then called *sensible* perspiration.

CHAPTER XVI.

ON THE SKIN (*continued*).

THE colour of the skin is owing to very small particles contained in the deepest little cells of the scarf-skin. The heat of the sun has a great effect on these particles. It darkens the colour of them, so that in a very hot climate the skin is dark, or even black. Other causes besides heat darken the skin, but the heat of the sun is the chief cause. A very fair skin will become freckled by exposure to the heat of a summer sun.

See how conveniently the skin is placed over the body, so as not to wrap it up too stiffly to prevent its moving.

Look at all those wrinkles on the knuckles. The skin there is left sufficiently loose, so that when the knuckles

are bent it does not crack; so it is at the other joints. You will observe many folds or wrinkles in various parts of the hands, even of a young child; but a young child's face has few wrinkles.

Fig. 32.*

How different is the face of an old person! How many lines are there! Many of these lines or folds of the skin are made by thoughts and feelings.

The spirit, who is acting in the brain,

* A child's face and an old wrinkled face.

can use the nerves of motion to alter the position of the face, and by these changes of position in the features of the face, the invisible spirit is able to tell in some measure without words what it thinks and feels. One position of the face speaks silently of joy, another tells of grief. Pain is expressed by another, and when the mind is perplexed by care, there is a mixed expression of pain and grief.

Thoughtful men, who study deeply, cast their faces into a serious form, and by and by the folds made by this means become deep furrows. If patient thoughts have made these deep furrows, or if they have been made by pain and grief, the face is sad to look at but it is not unpleasant.

Evil tempers, indulged till they become habits, leave lines that stamp the face into a form painful to look at. Good and kind feelings have their stamp also, so that a very old face of a person who has loved and thought kindly through life is a most beautiful picture. The expression cannot be

removed, the face cannot help looking good and kind. So you see the face is a tell-tale, and even on the outer skin there is a reward for goodness, and a punishment for unkindness and malignity.

CHAPTER XVII.

NECESSITY OF VENTILATION.

THE very minute particles that are continually flying off from our bodies in insensible perspiration, pass into the air and make it impure. This is another reason why the outer air should be freely let into rooms, because we not only diminish the oxygen gas by every breath, and substitute the poisonous carbonic acid, but we add this new substance to the air, which is not fit to breathe. Insensible perspiration passes from the bodies of all living animals; you shall hear a story of the ill-effects of it.

Perhaps you may have seen the monkeys in the Zoological Gardens. Monkeys often suffer very much from cold, when they are brought to England. In the woods, where they were free, they were used to

very great heat, and the cold and damp of our climate killed many of the weaker animals soon after they were brought over. It was determined to build a snug house for them in the Zoological Gardens, well heated by stoves, and never to allow them to breathe the open air.

The house was built, and very comfortable it seemed. Monkeys had never had so much care taken of them before. But poor things! Many of them were killed by kindness. The persons who planned the house knew very well that carbonic acid gas would have poisoned the monkeys; they also knew that it was the heaviest gas; they thought it would escape at the bottom of the room, so they contrived openings round the skirting-boards of the room. But they did not consider how impure the upper air would soon become by the particles passing from the monkeys' bodies in insensible perspiration. No opening was left by which this unwholesome substance could escape. The poor monkeys had to

breathe it again. It was even worse for them than the chilly outer air would have been. They died faster than if they had not had the warm house provided for them.

The people who meant to save their lives were very sorry; and they learnt more of ventilation (or the proper way of airing rooms) than they had known before.

We are sorry when we hear of such disasters happening to monkeys; but how much more sad it is when they happen to human beings! And they are occurring daily. If we live in comfortable airy houses, and if we have thoughtful friends who know how improper it is that even large rooms should be shut up long at a time, and who therefore supply us with fresh air, we have reason to be very thankful to the Giver of all good things. And whenever we feel thankful to God for any thing that we enjoy ourselves, we should ask how it is with others. Are all the people of England able to enjoy as much

fresh air as they ought to have? If not, can we do anything to make their bodies more healthy and serviceable. By learning to know what to be thankful for, now you are but young, you may one day or other be able to help persons who have less leisure to learn, and who are suffering partly because they do not know the reason of their sufferings. Persons employed in various trades suffer greatly for want of air.

They sit in low and crowded rooms for many hours together. The tailors in particular are much crowded at their work. In the London work-shops a great number sit together. A physician who visited these shops, and gave a description of them, said that, in a room sixteen or eighteen yards long, and seven or eight yards wide, he found eighty tailors at work. Tailors require heated irons to press their seams. The air in which they sit becomes very hot as well as very impure. When a young tailor, who has not yet become accustomed

to the atmosphere, begins to work in such a room, he sometimes faints away, and has to be carried out. The older tailors, who have long been accustomed to the foul and heated atmosphere, cannot bear a window to be opened; and indeed, the fresher open air, which would have saved them from much disease if they had allowed it to come into their rooms before they became sickly, now chills them and gives them colds and inflammations. Many tailors become consumptive, and die early from want of good air to breathe. In the evening, each tailor lights a large candle with a thick wick, that he may have plenty of light for his fine neat work. Flame is fed by oxygen gas. It burns that gas only, so that lighting the candles diminishes more and more the gas fit for life. This room was only a specimen of the multitude of crowded unhealthy rooms in which workmen prepare the variety of articles we see in the shop-windows or wear on our own persons. Milliners and dress-makers suffer much from want

of air; they do so even in country-towns. They sit many together in close rooms, and become very sickly in consequence. Their labour is in many cases too hard for their strength, but they would bear the daily toil far better, if those who have the charge of them had the rooms in which they sit well ventilated, and allowed them daily exercise in the open air.

CHAPTER XVIII.

THE TEETH.

HERE is a picture of two teeth. One is a front tooth and the other a back tooth. The back tooth has three roots

Fig. 33.*

or fangs, the front tooth only one. The fangs are rooted into sockets all along

* 1. Incisor tooth and molar tooth. 2. Front view of jaw showing the teeth.

the jaw-bone, and covered by the gums. That part of the tooth which comes beyond the gum is called the crown of the tooth. No teeth are to be seen in a very young baby's mouth: the little baby does not require teeth; it lives on milk, and has not to bite anything. Under the baby's gums there are little bags which contain a pulp. That pulp hardens, and at last becomes a bone, and pushes its way through the skin of the gum, and then we see a pretty little white tooth beyond the red gum. This tooth is coated with a beautiful, shining, strong enamel; for common bone would soon wear out, and the strong enamel preserves the teeth better than anything else would. As soon as the baby ought to bite anything it has teeth to bite with. They grow through the gums one after another till the baby has twenty. By the time that it has twenty it is about three years old. These teeth are called its milk teeth.

They are not *very* strong teeth, but they

are quite strong enough for the food which the little child ought to have. Close by the side of each tooth there is a little bag with pulp in it, and these little bags are the seeds or the buds of the second set of teeth. There will be more teeth in the second set than in the first. There are buds enough for thirty-two new teeth; for the child's jaw-bone grows larger, and gives room for twelve more teeth; they make up the thirty-two teeth. Gradually the little buds near each tooth become harder and larger, and the fangs or roots of the first teeth waste away. Only the crowns of the first teeth are left at last. They easily come out, and the new and stronger teeth take their place.

Fig. 34.*

When the child is twelve or thirteen, there are twenty-eight teeth, but as he

* Diagram of the rudiments of new teeth.

grows up to a young man or young woman, there will be four more teeth, one at the top and one at the bottom of each jaw. These are called the wisdom teeth, because they come when people are old enough to be wise. Very great care ought to be taken to preserve the second set of teeth. Nothing preserves them so well as keeping them quite clean. They should be washed and brushed every morning and every night. It is even more necessary to brush them at night than in the morning, because some of the food which we have put into our mouths to grind, may have lodged in the teeth, and if it is not removed it injures them. We suffer great pain when they decay, or when they are pulled out, and the reason is this. The roots or fangs of our teeth are hollow, and into this hollow fang the nerves as well as the blood-vessels pass. When the crown of the tooth, which covers up the ends of these nerves from the air, is worn away by decay, the food we eat touches

the nerves, and this gives us great pain. You will remember that the nerves of the under skin are covered up by an outer coating of scales, that every touch might not give us pain. The crown of the tooth is a covering for the nerves in the fang.

Fig. 35.*

When persons become old, they lose their teeth. Very aged people, unless they are unusually strong and healthy, have lost all their teeth. The skin of the gum grows over the sockets in the jaw-bone. When aged people have lost all their teeth, they only require such food as needs very little biting. For the whole of the body within, the lungs, the heart, the stomach, are all weak, and the loss of their teeth warns the aged that they should not give their stomachs too much to do. The jaw-bone has a hinge-joint so made, that besides moving up and down (as when we open and shut our mouths) it will also move

* Section of a tooth.

from side to side; this is for grinding the food. Remember that the food should be very much ground up in your little mouth-mill.

CHAPTER XIX.

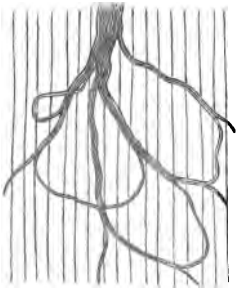
THE SENSES: FEELING—TASTING—SMELLING.

YOUR ownself, your spirit, that part of you that makes use of the body, has to learn how to make use of the body. If you sat down and tried to play on the piano before you had learnt, and practised to do so, you could not make any proper use of the instrument; you would not know how to play it. If you observe a little baby you will see that the spirit within is learning how to use the many parts of that small instrument, its body. It can use the hinges of its legs, and all the joints of its little frame to kick and sprawl, but it cannot walk. It cannot make all those movements with the tongue and lips which you make whenever you

speak. You learnt to do that very slowly by trying very often, and baby will do the same. But it learns many things before it learns to speak. Baby does not learn lessons. It does not come into the school-room with you to learn from books, yet it is learning other things as fast as you. The spirit in the baby comes into quite a new world; everything is very wonderful to the baby. You have seen the light of day, and the bright clouds in the sunshine, and the green fields, and the flowers, and all the pretty things in your nursery so often, that they are not so new as they are to baby, who has to learn and see them all for the first time. The baby's spirit can learn about the outer world in five ways; by smelling, tasting, feeling, hearing, and seeing. The nerves of sensation, as you have already heard, carry messages from all parts of the body to the brain. The nerves branch out in the same way that the veins do, and like them end in a fine net-work. This net-work,

composed as it is of the nerves divided out into so many threads, is very sensitive. that is, it carries very readily its impression of the slightest touch to the brain. The net-work of nerves at the tips of the fingers, makes them so very useful to feel with. The baby learns the shape of things, and their qualities of roughness, smoothness, &c., by feeling them.

Fig. 36.*



We might learn very much more than we do by the sense of feeling. We can tell this by what blind people are able to do. The net-work of their nerves at the tips of their fingers is just the same as ours; but they can make it much more serviceable than we do, if they are taught to do so by kind and patient people. Dyes

* Diagram of a nerve ending in net-work.

of different colours are rather different in their quality of roughness and smoothness. Blind people can feel the difference after much practice; the names green, red, blue, have no meaning to them except as conveying a rougher or a smoother sensation to their fingers, and by this difference they know them apart.

They can also learn to read by feeling. Cards have been printed for the blind, on which letters are embossed. They distinguish the different shapes of the letters readily by their touch. The names belonging to the shapes are taught them by those who can see; and after much practice they are able to read easily.

There is also a close net-work of nerves over the tongue. The different things that we put into our mouths to eat touch the nerves differently, giving us what we call different tastes.

The inner part of our nostrils is another part of the body, which is closely covered by a net-work of nerves. It is very curious

to think how it is we smell anything. When we put a flower or a sweet scent of any kind to our nose and enjoy the smell of it, it is because the nerves lining our nostrils are touched by very little particles (much too small to be seen) which fly off from the flower or scent. Besides the sweet scents, such as those from violets, roses, lavender, &c., there are unpleasant scents, and these are given to warn us that the air has something in it which is not good for our health.

Many unwholesome gases have an unpleasant smell; but there may be particles in the air so very minute as not even to be felt by the nerves of our nose, which yet would make us ill by being taken into the lungs. We do not think much of the sense of smell as if it were very useful, though we know it is pleasant to have sweet scents brought to us in the summer air, over beds of flowers, or hay-fields, or in any other way. Yet the sense of smell is very useful. By it we are warned to

keep our houses well aired and healthy. Where other senses have been lost by disease, it has been made more serviceable than we should have believed possible. There was a man named James Mitchell. He was deaf, blind, and dumb, from his birth. He learnt more from his sense of smell than you would have thought possible. He could distinguish different people by this sense.

There was once a blind gentleman who very much disliked cats. The reason was that he could find an unpleasant smell from them when no one else could smell them at all. One day he was quite sure that a cat was not very far off. No one could see it anywhere. Search was made, and pussy was really found shut up in a closet.

Humboldt, a traveller who went very much among the American Indians, says, that if any of the neighbouring tribes came to a village in Peru by night, the Peruvian Indians could tell by the smell which

of the various races was drawing near. And if it was none of their neighbours but a party of Europeans, they could distinguish them in the same way from the rest. These Indians were not blind, nor had they lost any of their other senses, but they had practised smelling much more than we do. They had learnt when very young to follow the track of animals which were to serve them for food. Just as the savage who had made his naked feet serve for hands in catching fish, these Indians make their noses serve a better purpose than eyes, for they can track an animal by his scent when he is far out of sight.

CHAPTER XX.

THE EYE.

You have heard now about three of the senses — feeling, tasting, smelling. The contrivances by which we feel, taste, and smell, are more simple than those by which we see and hear.

The two eyes are, as you know, the parts of the body through which we see. A deep bony socket contains the eye; the part of the eye which we see is only the front of it, and it goes deep into the head. It is in shape like a globe. It has a complete case enclosing it altogether. The front of the case may be compared to a watch-glass, the edges of which fit the watch-case. The edges of the cornea, or transparent front of the case, fit closely to the sclerotica, or rind enclosing the back part of the eye.

In front of the eye there are two fringed curtains (called lids) which are easily shut whenever anything comes near which might injure the eye. But within the eye there is a more delicate curtain still. A coloured curtain called the iris. It is differently coloured in different people. Sometimes blue, or very dark brown, or light brown, or greenish, or grey. We call the eye blue, or brown, or grey, &c., according to the colour of the iris. That delicate curtain the iris has a round hole in its centre which is called the pupil. Through this hole we see deep into the eye, and for that reason it looks so dark. When we turn our eyes towards a strong light, the pupil becomes small as the iris contracts, so as to make the opening less. When we shade our eyes the pupil is much larger, as the iris dilates so as to make the opening larger, and the eye looks

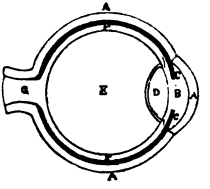
Fig. 37.*

* Eye and iris.

blacker as we see more of the dark inner chamber.

Under the cornea (A) there is water (B), called the aqueous humour. Just behind the iris (C) there is a very thick little lump of a clear bright substance, like glass or crystal. It is called the crystalline lens (D). Behind it there is another clear transparent substance, not hard like the crystalline lens, but just as bright. It is like the clearest jelly. This is called the vitreous humour (E). Behind the vitreous humour there lies stretched all over the inner part of the back of the eye the end of a nerve, called the optic nerve (G), a nerve of sight, and the part spread out is called the retina (F). The nerve comes from the brain to the back of the eye through a small hole in the skull. If

Fig. 38.*



* Section of eye.

this nerve were broken or injured, the spirit within has no other way of getting at its instrument (the eye) to use it. The lenses and all the other parts might be perfect, but they would be useless, if they could not be acted upon from the brain. The eye so injured would be blind.

I will repeat the names of the various parts of the eye.

The case to hold all, called the sclerotica and cornea; the iris, with a hole in the centre called the pupil; the aqueous humour; the crystalline lens; the vitreous humour; the retina, and the optic nerve.

These are the various parts which, when put together in their order, make the seeing instrument called the eye. A picture of everything we see is formed on the retina or optic nerve, spread out. It seems almost too wonderful to believe that a wide prospect—the distant ocean, rocks, woods, valleys, corn-fields, should be pictured in their exact shapes and colours on so very

small a space as the dark back-ground of our eyes.

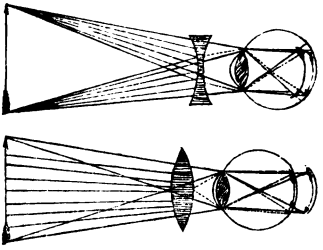
Have you seen a camera obscura? The dark chamber (from which the instrument is named) may represent the retina of the eye. Glasses are so arranged by an ingenious contrivance that the images of external objects in front of them are pictured in the dark box. These glasses serve the same purpose as the lenses and humours of the eye.

Daguerreotype pictures are made by placing a prepared metallic plate in a similar box to that of the camera obscura. The picture from without is thrown on the plate, and the sun acting on the metal (prepared for that purpose) fixes the picture there.

The lenses and humours of the eye are formed with great exactness when the sight is perfect. Near-sighted persons have their lenses and humours so formed that the eye is a little too deep. In far-sighted persons the eye is a little too shallow. You may see

in the upper figure in this picture that when the humours, &c., are a little more in quantity than they should be, so that the eye is a little too deep, the perfect

Fig. 39.*



picture of objects does not fall on the retina, but a little in front of the spot on which the perfect picture should fall, so that the retina receives an enlarged image, not so clear as the perfect image. In the lower figure you may see how it

* 1. Diagram of image falling short of the retina (short sight). 2. Diagram of image beyond the retina (long sight).

is when the humours, &c., are a little too small in quantity, so that the eye is not quite deep enough, and the spot on which the perfect picture would fall is a little behind the retina, and not exactly on it. An imperfect image in this case also reaches the retina. To correct these defects spectacles are used so as to make the image fall exactly upon the retina. The humours of the eye are all transparent, but they are of different substances and of different shapes. It is by such an arrangement that the true colours of objects are pictured in our eye. At one time it was found impossible to arrange the glasses of telescopes so that the colours of objects imaged in them should be represented as well as their forms, and it was only by imitating the structure of the eye, and putting several glasses together of different shapes, and made of different kinds of glass, that an image coloured perfectly, like the natural one, could be formed.

The cornea of the eye resembles glass, the aqueous humour is like water, the crystalline lens like hard clear jelly, the vitreous humour like soft clear jelly. The science of optics, which perhaps you may one day study, teaches how it is that this variety of transparent substances is essential to the transmission of colours.

CHAPTER XXI.

STORIES OF THE BLIND.

How melancholy it would seem to be shut up, if but for one long summer day, in a dark room! Then we should know what thankfulness we owe to God for the light of day, and all the beauty light brings to our eyes. Among our fellow-creatures there are great numbers who live wholly in the dark. They go about the world and see nothing of its beauty and glory. Their instruments of sight are so damaged that the mind within cannot use them. But when cut off from gaining knowledge by the use of these very valuable instruments, the mind of a blind man is all the more diligent in the use of its other instruments.

His hearing becomes very acute from the attention he gives to sounds; his touch,

because he feels where others look, and frequently also his smell. It is well for us to notice how actively the mind may work without one of its instruments, because if we have all our instruments uninjured, how much more should we gain of skill, and knowledge, and wisdom, than those who are so afflicted. Yet we shall see by some instances, out of a great number that might be told, that we are far behind some whose advantages have been much fewer than ours.

Blind men have become great poets, philosophers, musicians; but as I can give you only two stories of the difficulties overcome by blind people, I will take them from those whose minds were not particularly gifted with uncommon powers, as the minds of the blind poets certainly were.

William Kennedy was born in the county of Down in Ireland, in the year 1768. At four years old he became quite blind. When he grew to be a great boy, he did

not like the thought of being burdensome to his family. He wished so much to earn his own living, as he heard other boys of his age could do. His friends knowing his wish, thought he might at least learn the fiddle, as many blind boys had done before him; so they took for him a lodging in the town of Armagh, and he began to take lessons with other boys who had their sight. In no long time he could play the fiddle better than any of Mr. Moorhead's (his master's) pupils but one. But he had done something else at Armagh besides learning the fiddle. His lodging was in the house of a cabinet-maker. William had spent all his spare time in feeling the tools of his host, and in learning the shape and names of them all, and the names and shapes of the articles of furniture on which the cabinet-maker worked. When he went home to his native town of Banbridge, he got tools for himself, and succeeded in making some household furniture. Then he borrowed an old set of Irish bag-

pipes. They were so much broken and worn as to be unfit for use. He worked patiently until he had repaired them; and while, by means of his touch (which had become very delicate), he learnt the mode in which all the pieces of which the instrument is composed are fitted together, he designed an improvement in the construction, which he was strongly persuaded he should one day be able to carry out. The neighbours soon learnt what blind William had done, and from all the country round old bag-pipes were sent to him to repair. He worked diligently, and in time made a new set of improved bag-pipes for himself. Hearing that a clockmaker in Banbridge wished to learn to play on them, Kennedy offered to teach him if in return he would let him learn something of watch- and clock-making. His sense of touch must have become wonderfully delicate, for he succeeded in learning this new trade. It enabled him to earn more than he could have done by merely repairing instruments.

He married, and in due time had a family, and supported them by the labour of his hands. These useful hands were now ready to work at several trades, and thus were always kept employed. Sometimes blind William was making furniture, sometimes linen looms, which in his country are used so much for making Irish linen, sometimes repairing bag-pipes or fiddles. How many with the full use of their eyes might take a lesson from him!

The other story that I shall tell you is of a young French lady, Mademoiselle de Salignac, who at three years old became blind. She was a gentle, affectionate, and sensible child. She had not, like William Kennedy, to struggle for herself in the world. Her own parents and friends took great pains to instruct her, and her natural intelligence made it a pleasant task to them. She quickly learnt to distinguish all her family and friends by the sound of their voices. She could tell whether she were in a large or small room by the sound of her

footsteps in it, or other sounds. She knew the different sensation of a cloudy day and a clear one. She found her way about the house so as to go any where alone, and if she were taken to a strange house she soon learnt the plan of it. She was always happy to sit silent, if she could hear others talking, and it gave her so much enjoyment to hear that she did not much care to be a talker herself. But it pained her to listen to conversation if the evils of the tongue were indulged. She could not bear that any one should be blamed or spoken against, for her heart loved all. All were so kind to the blind child.

Blind people delight in music, and Mademoiselle de Salignac learned to play on the violin and to sing. When she grew up it made her happy to play to her young sisters and brothers and their friends, while they danced round her; and she often sang to them or alone. "I am," she said, "like some birds, I sing in the dark." She was taught to read by means of letters cut out,

and she learnt the notes of music by having them embossed on cards with raised lines. She could write also in her way, not with pen and ink, but by pricking the letters with a pin. Her friends had a frame made, into which a sheet of paper was fixed. Two moveable metal rods crossed the frame; these served for lines. Having pricked one line, she could slip them down for the second, and so on. Her fingers were very active in needle-work. "She made purses and bags, plain, or with fine open work, in different patterns, and with a variety of colours; garters, bracelets, and collars for the neck, with very small glass beads sewed upon them in alphabetical characters." She understood the elements of astronomy, algebra, and geometry. M. Diderot, who knew her and conversed with her, was often astonished at the clearness with which she would explain what she knew in geometry, on his asking her questions in that science. She remembered with great accuracy the forms of animals, plants, &c., and if a figure

of one were traced on the back of her hand with the finger, she could tell what it was. Her active spirit was called away early from its dark dwelling. She died at the age of 21.

These two blind people, and many others of whom you may read, were active and useful throughout their whole lives. Blindness must be a much greater affliction where the person has not the energy of William Kennedy, nor the kind friends of Mademoiselle de Salignac. Happily in our own and other countries there are asylums for the blind where they may be instructed.

CHAPTER XXII.

THE EAR.

THE instrument for hearing is the ear. The spirit within gets at its little hearing instrument in the same way that it reaches all other parts of its body; that is, by nerves. Nerves come through small holes in the skull to the inner part of each ear. The outer part of the ear you can see, with its curved open passages. But did you ever think of the use of those passages? They are to collect the sounds that reach them. Here is the outer ear. Here is a pipe which leads from the outer ear deeper into the

Fig. 40.*

* Diagram of outer and inner ear.

head. It is about an inch long. A thin skin closes the pipe at the inner end. It is strained very tight like the parchment over a drum-head. It is called the drum of the ear. Behind it there is a beautiful chain of little bones, shaped as you see in the picture. The last of them is like a little stirrup. It is fixed to another thin skin, which closes the cavity in which the chain of bones is placed. Behind the stirrup there is a bony chamber in which are winding passages. Here are the winding passages. The part marked is named after a snail shell, from its spiral shape. Here is the spiral-shaped part (or cochlea).

Fig. 41.*

Fig. 42.†

All the passages and tubes of the bony chamber of the ear are filled with water. The nerve by which the spirit within re-

* Chain of bones of the tympanum.

† Cochlea and semicircular canals.

ceives the sounds which come into the ear, leads from the brain to this winding chamber, and the ends of it are divided and spread about over the passages and cells. So the sounds that come to our ears have first to pass along the open passages of the outer ear, then to go down the pipe and strike the drum, then to travel along the chain of bones, then to pass through water. If the sounds we hear struck at once upon the nerve, they would give us great pain. If anything else besides sound were to get into the ear, it would be very painful to us. The pipe leading to the drum is therefore lined with bitter wax. This keeps away small insects, which might otherwise creep or fly in.

Something must strike the nerve of hearing, or we should not hear. What is it then that strikes this nerve? Only air passes down the pipe of the ear. It must therefore be particles of air set in motion which strike the drum of the ear.

If a bell is placed under a glass, and the

air pumped out of the glass (which can be done by a machine called an air-pump) we cannot hear the bell ring, because there are no particles of air which can be struck by the motion of the bell.

When you ring a bell you pull the bell-handle which moves a wire, which moves the bell, which moves the clapper, which strikes the side of the bell, and moves the particles of which it is made. Although we cannot see the motion of these particles, they do move a little out of their places and back again, and this motion moves the air round the bell, and throws it into waves, very nearly like water is thrown into waves when a stone is dropped into it. One of these air-waves, or undulations, strikes the drum of the ear, this moves the little chain of bones, and these set the water in motion in the winding passages, throwing it into waves, which strike the nerve of the ear, and this produces what we call sound.

We have compared the movements of the

air by which sound is transmitted, to the waves produced by a stone thrown into a pond. If you drop a stone into still water, and watch what takes place, you will see that a circular wave, like a ring, immediately begins to travel onwards from the place where the stone plunged into the water, and this circular wave increases in size until it reaches the edge of the pond, where it breaks upon the shore. But this wave which touches the shore is not the very same water which the stone disturbed and moved. The stone moved the particles of water all around it, and these particles only moved a little way, and pushed on those next to them, and these pushed on the next.* As when in your play you place a row of bricks on their ends near enough together

* This illustration is sufficiently near for the purpose. The true difference between the undulations of water and those of sound, is, that whilst the former are vertical to a surface and extend in circles, the latter are propagated in all directions and extend in increasing spheres, the undulations being in a direction at right angles to the surface of those spheres.

for one to touch the rest when it falls, and then by overturning one of the bricks at one end all fall, as the first moves and knocks down the second, and this in falling makes the third fall, and so on until the whole row falls. So it is with the air in sound. The bell or any other cause of sound moves the particles of air next it, which push on the particles next to them, until the motion reaches the drum of the ear, and is conveyed to the nerve, and by the nerve to the brain and to the spirit.

Now it is most probable that we see in much the same way. That light is a motion which throws either the air or something thinner than air into waves which strike our eyes, and the motion is passed on through the transparent cornea, the aqueous humour, the crystalline lens, and the vitreous humour, to the retina or nerve of the eye, spread out over the back of the eye, and then on to the brain itself by the optic nerve.

CHAPTER XXIII.

INSTRUCTION OF THE DEAF AND DUMB.

THE ear is in some persons quite useless. Some are born totally deaf. If totally deaf they are dumb also, for it is by the use of our ears that we gradually learn to imitate the sounds made by others. If persons have become totally deaf after having once acquired the power of speech, they can then speak so as to be understood, though they never hear the sound of their own voice.

Happily the deaf can be instructed by means of signs, and when once they are taught to write and to read, they may have great enjoyment, though everything is silent for them. A good French abbé, the Abbé Sicard, devoted his life to the instruction of the deaf and dumb. One of his pupils,

who discovered great ability after he was instructed, was able to recall some of the thoughts and feelings he had when he was very young and untaught. Massieu, for that was his name, well knew that there was something in him different from the rest of his companions. He saw them trooping off to school with their books, and he was left behind. He made signs that he too wished to go to school, and felt angry when forbidden. He thought that the skies and the stars had some strange power, for when his father knelt to pray he made him kneel beside him and look upwards. His mother was ill, he longed for her to be well, and looked up to a particular star with this desire in his heart, and when his mother grew no better he was angry with the star, and threw stones at it. Travellers pitied the lonely boy who might be seen by them at times watching a flock; some gave him money. One gentleman did more. He could not forget Massieu when he left La Gironde, where the

boy lived, and he did not rest till he had put him under the care of the good Abbé Sicard. With him he was taught to read and write, and then received truths which commonly reach the minds of children in their very earliest years, but which were new and fresh to him. He wrote an account of himself. In it he says,—"Now I know there is a God, who is the Creator of heaven and earth. In my childhood I adored the heavens not God. I did not see God, I did see the heavens. I did not know whether I had been myself made, or whether I made myself. I grew tall. But if I had not known my instructor Sicard, my mind would not have grown as my body, for my mind was very poor; in growing up I should have thought the heavens were God." "I knew the numbers before my instruction, my fingers had taught me them; but I did not know the figures. I counted with my fingers, and when the number passed ten, I made notches on a stick." The deaf cannot imagine what

sound is like, they can only compare it to sight. Massieu said, "The hearing *see with their ears* during the night, a person who is walking." Massieu grew up to be a thoughtful and intellectual man. He had great natural abilities, and when once he was instructed in reading so as to learn the truths of the visible and invisible world, perhaps in his total stillness he could reflect more deeply than other men whose minds are partly occupied and distracted by sounds. He gave beautiful answers in writing to questions proposed to him.

The following are some of them.

"What is hope?"

"Hope is the blossom of happiness."

"What is the difference between hope and desire?"

"Desire is a tree in leaf, hope is a tree in blossom, enjoyment is a tree in fruit."

"What is gratitude?"

"Gratitude is the memory of the heart."

"What is time?"

"A line that has two ends, a path that

begins in the cradle and ends in the tomb."

"What is eternity?"

"A day without yesterday or to-morrow; a line that has no end."

THE END.

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